CAMED: An Innovative Communication Tool in Teaching Engineering Drawing

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Abstract:- Technical drawing is an important basic communication tool in engineering drawing. Besides student ability, teaching strategy also plays a prominent role in enhancing student's learning. This paper aims to discuss students and teachers perception on an innovative teaching method? of engineering drawing subject at secondary school level. The strategy employs Computer Animated Module for Engineering Drawing (CAMED) which was developed based on constructivism and cognitive load learning theories. Furthermore the effectiveness of the module on student's achievement, conceptual understanding and problem solving skills is also discussed. A quasi experimental method was employed on 110 students in the treatment group and 109 students for control group respectively. There were five teachers involved in giving feedback on the module. The result revealed that both students and teachers have very positive view on this innovative way of teaching and learning. In addition, the results also show better achievement, understanding of the concepts and knowledge on problem solving among treatment group students as compared to the control group. It indicates that the application of animation is an effective way to help teacher's teaching and enhancing student's learning. Therefore it is suggested that more of such module should be developed for other topics.

Key-Words: Computer Animation, Engineering Drawing, Computer Aided Instruction, Educational Technology, Multimedia Communication

1 Introduction

Technical or Engineering Drawing (ED) is a communication media which is graphic based and is widely used in the engineering field. It communicates by using simple and exact symbols, as well as conventions with its own procedures and standards. In the Malaysian school system, Engineering Drawing is included in the Secondary School Integrated Curriculum since 1994 [1]. The subject is introduced as an early exposure to the technical subject and as a preparation for students who are interested to further their studies in engineering. In a normal practice students' achievement are gauged through the Malaysian Standardized Examination (SPM). The SPM results of ED subject since 2003 to 2008 showed an increase (Table 1) in its overall percentages for the number of students passed but percentages of students who obtained excellent and moderate grades are still low (below 50%).

Table 1 SPM Results of Engineering Drawing Subject

Year	Excellent Grade	Moderate Grade	Low Grade	Passed
2003	15.3	44.5	40.2	78.50%
2004	17.7	50.3	32	86.80%
2005	18.6	49.7	31.6	86.40%
2006	20.3	49.2	30.5	87.00%
2007	18.7	52.7	28.7	88.90%
2008	20.3	49.2	27.2	90.30%
Average	18.5	49.3	31.7	86.30%

From the analysis above, it can be concluded that students' achievement in ED subject have low percentages in the quality of grades obtained even though the quantity of passes increases. The discrepancy between the quality and quantitiy of grades warrants us to investigate the cause to such results. According to [2] here exist some challenges in engineering subject related to its pedagogy. Often learning outcomes are hard to achieve and also difficult to assess. It need diverse teaching and learning approaches specific for the subject. New, innovative and effective way of teaching and learning should be employed to motivate students' learning hence lead to more quality achievement.

1.1 Information Communication Technology in Education

The use of technology especially Information Communication Tecnology (ICT) in education can bring some changes in how teaching and learning happen in the classroom. ICT application allows more interactive learning and students participation in class activities [2-3][4]. Beside that, it can also assist students in gathering and exchanging information as well as information processing for better understanding. Furthermore ICT helps students to visualize the real world situation and use their existing knowledge to enhance their understanding about the problem and its context [5]. In that way abstract concepts can easily be understood [6]. According to [7] [ICT is a good tool to be used to enhance students learning in engineering subject. ICT, in this context , is the use of computer with multimedia software to facilitate students learning especially in problem solving [8]. It can be used to assist students in exploring and discovering concepts, tranforming from concrete ideas to abstract and enhancing student's knowledge. Research has shown that problem solving activities can be effectively implemented using computer where students showed positive attitude in their ability in problem solving [9].

Another important element in computer communication is the application of animation. According to [7] animation has some advantages such as; it can show consistent transition, rich with graphic presentation, constant change, three dimension visualization and can attract user's attention. In problem solving, animation can be used to explain abstract concept through better and effective demonstration. Researchers have agreed that visualization is one of the important factors in explaining concepts for certain topics. Most Literatures on computer animation in teaching and learning shown positive effect on enhancing student's achievement, motivation and understanding of the concepts learned [10-15] especially those of the abstract and difficult concepts. In addition, study by [16-17] confirmed that the application of animation helps the teaching and learning processes. Therefore animation can be used to assist students to have better visualization in understanding concepts through its transformation and transition [4].

It is important to note that ICT in this study is used as a tool to support and enrich teaching and learning activities. The innovative teaching and learning method of ED is implemented using Computer Animated Module for ED (CAMED). This software is developed based on Sistematic Planned Model, constructivism and cognitive load learning theories and the integration of problem solving strategies using Power Point application.

2 Problem Formulation

Based on the earlier studies [2][18-21] the main problem faced by the students in learning ED was the difficulty in understanding the fundamental concepts in geometrical drawing. In general, ED requires student to have high ability to imagine, think creatively and observe precisely. In the syllabi of ED, there are many concepts that students need to understand and master in before they are able to understand, define and solve ED problem because by not having these abilities it will deter them from explaining and interpreting the phenomena correctly [21][23]. In addition, by not understanding the previous knowledge and skills fully will make further learning process more difficult [7]

In the studies done by [2][18-21] they also showed that students lack of motivation, less interested and lack of self-confident. On the teachers' part, they found that they were having difficulty in allocating appropriate materials for the teaching and learning of engineering drawing.

Based on the above problems, it is therefore timely to plan, design and try out the systematic and innovative way of teaching and learning ED in order to address the problems faced by the students and teachers. Hence the aims of the paper are two folds first to analyse the assessment done by the students and the teachers on the feasibility of the module in the pursuit to obtain its learning outcomes and second to analyse the effectiveness of CAMED on student's achievement in ED test, mastery of concept and mastery of problem solving knowledge

3 Methodology

There were four phases in the study which were the need analysis (phase 1), the development of computer animated software (phase 2), the feasibility study (phase 3) and the effectiveness study.

3.1 Phase 1: Need Analysis

At this stage the researchers employed a questionnaire aimed at identifying the problems faced by students and teachers in the process of learning and teaching engineering drawing. The initial findings guided the research by focusing and prioritizing the problem that need to be solved.

3.2 Phase 2: Development of Computer Animated Engineering Drawing Module

The development of the software was done on the topics of Tangent, Ellipes and Parabolic (TEP) where most students have difficulty in understanding its concept in ED. A specific animation was used to explain the processes of drawing TEP. The *Microsoft Office PowerPoint* animation application was used in the development. The animation used was to assist the teacher in explaining effectively the processes to the students thus enhancing the students' understanding. Using the animation application, teachers and students were able to replay or repeat the steps in the processes of drawing the concepts in TEP topics until they are confident that they had had acquire the concept and competency. Teacher can also reduce the time needed in repeating the drawing manually.

The 2D linear animation was used because it is simple and does not require a high computer capability. two types of animation namely cell animation (frame by frame) and path animation (true time animation) were employed. To make the program more interesting all drawing equiptments were developed as close as real objects. Figure 1 shows the example of the module developed.

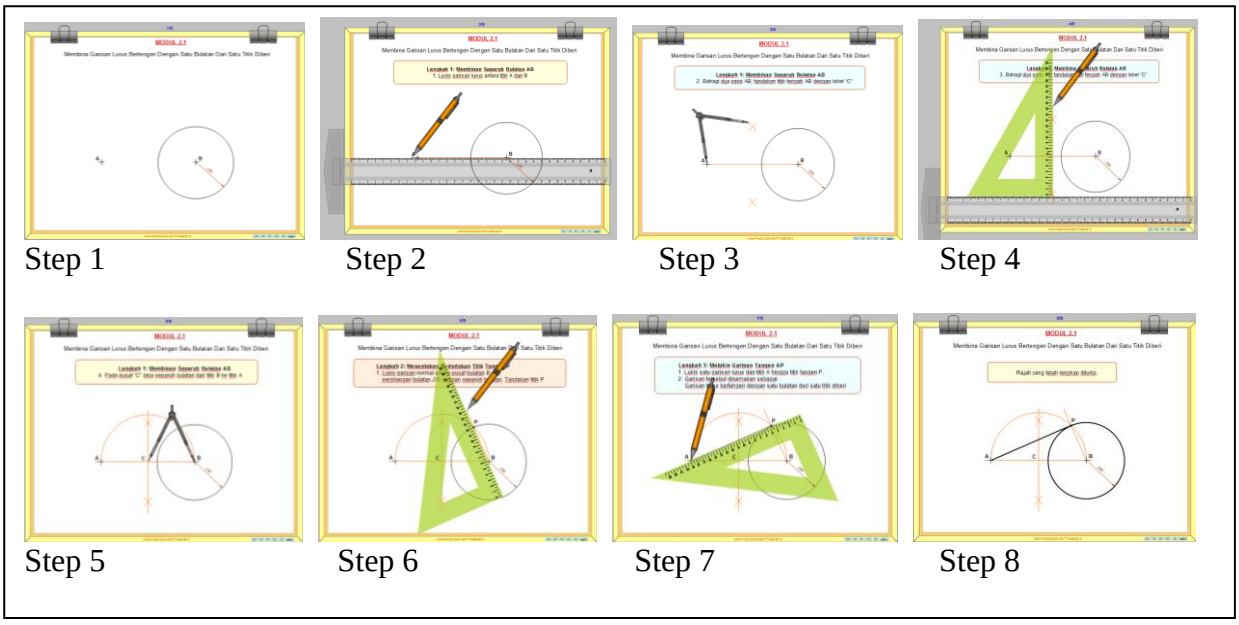

Fig. 1: Example of The Module Developed

3.3 Phase 3: The Feasibility Study

A survey questionnaire with Likert scale and open ended items was employed in getting the data from 110 students and 5 teachers who taught six different classes in a technical school chosen. The questionnaires used were the teachers' and students' evaluation on the animation application and the questionnaires on students' and teachers' perception on the ability of the module to improve students understanding of the concepts, motivation and self-confident. The reliability measure of the questionnaire is considered high with *Alpha Cronbach* value between 0.731 and 0.913. The descriptive statistics of frequency, percentages, means, and standard-deviations were used in the analysis.

3.4 Phase 4: The Effectiveness Study

For the effectiveness study, a quasi experimental design was employed where intact classes were used [24] (Johnson & Christensen 2000). Two sampling techniques were applied. First the purposive sampling technique was used to choose schools that have similar characteristics and second, simple random sampling technique was used to choose two technical schools from eight identified schools that have similar characteristics. From these two schools, one is assigned as the experimental group and the other as a control group with 110 and 109 students respectively. The experimental group experienced the teaching and learning using CAMED whereas the control group used only text books and blackboard without CAMED in the teaching and learning activities. The pre and post test on ED assessment were employed to both experimental and control groups to measure the effectiveness on the student's achievement of ED. The pre-test was employed to assess their initial ability. It was found that both groups had equal level of initial knowledge. The post-test of conceptual understanding and problem solving knowledge questionnaires were also given to both groups after the lesson. The realiabilty measure for the instrument is between 0.731 to 0.917.

Data were analysed using SPSS version 17.0. Descriptive and inferential statistics were used where means, standard deviation and independent t-test were respectively used. The indepenent t-test was used to compare the mean difference between the mean score on the post-test of the experimental group and the control group.

4 Findings

This part will only present the data analysis of the third and fourth phases.

4.1 Results of the Feasibility Study

The findings are based on teachers' and students' evaluation of the feasibility of the developed module-Computer Animated Module (CAMED). The evaluation is based on three criteria: a) the appropriateness of the content of CAMED, b) the suitability of CAMED in terms of enhancing students' understanding, motivation, interest and self-esteem towards learning Engineering Drawing and c) the overall suitability of CAMED. Teachers and students were also asked to respond to the open ended questions regarding CAMED. Table 1 presents teachers' and students' view on the appropriateness of the content of the developed CAMED.

Based on table 1, both teachers and students regard the content of CAMED is highly appropriate, with mean score between 4.15 to 4.87. This indicates that both the teachers and students consider CAMED to be an appropriate and it is seen as an effective learning and teaching aid. Table 2 shows teachers' and students' views on the overall feasibility of CAMED.

Table 1 Teachers and Students views on the appropriateness of the content of CAMED

	Views on the appropriateness of animation	Teacher			Student		
		M	SD	Level	M	SD	Level
1.	Object introduced in animation is able to relate to the concept	4.23	0.440	EH	4.24	0.736	EH
2.	The graphic is appropriate and easy to view	4.23	0.436	EH	4.28	0.688	EH
3.	'Step by step' method for constructing the diagram is easy to understand	4.23	0.431	EH	4.30	0.658	EH
4.	Animation related to construction of steps is able to enhance students' interest in learning ED	4.41	0.506	EH	4.29	0.703	EH
5.	The animation is as in the real situations	4.42	0.534	EH	4.27	0.673	EH
6.	Animation related to construction of steps is able to enhance students' confidence in learning ED	4.43	0.520	EH	4.20	0.720	EH
7.	Learning objectives are stated clearly	4.44	0.517	EH	4.15	0.697	H
8.	Students' prior knowledge is clearly stated	4.44	0.517	EH	4.20	0.732	EH
9.	Concept of diagram construction shown through animation is able to explain the method of diagram construction clearly	4.46	0.509	EH	4.24	0.663	EH
10.	This animation can be used by teachers in teaching and learning sessions	4.47	0.468	EH	4.33	0.665	EH
11.	The animation is able to focus students' attention on learning ED	4.49	0.482	EH	4.24	0.767	EH
12.	Animation related to steps in construction shown can enhance students' motivation in learning LK.	4.61	0.416	EH	4.27	0.697	EH
13.	Animation related to steps in construction shown is able to achieve the learning objectives	4.63	0.482	EH	4.29	0.705	EH
14.	Moral values to be achieved were clearly stated	4.67	0.472	EH	4.17	0.717	H
15.	Animation related to steps in construction shown is able to promote students' understanding on the concepts of TEP	4.87	0.253	EH	4.31	0.673	EH
	Total Mean	4.47	0.470	EH	4.25	0.700	EH

Note * H= High EH= Extremely high.

Table 2 Teachers' and students' overall views of CAMED

	Items	Teacher			Student		
		M	SD	Level	M	SD	level
1.	This module can increase students' achievement in ED subject	3.80	0.447	High	4.06	0.685	High
2.	This module can promote students' confidence in learning ED	3.80	0.447	High	4.01	0.732	High
3.	This module can increase students' motivation in learning ED	4.00	0.707	High	3.94	0.837	High
4.	This module is able to promote students' interest to learn ED	4.00	0.707	High	4.10	0.679	High
5.	This module helps students to understand the concepts of TEP	4.00	0.707	High	4.12	0.700	High
6.	This module is able to enhance students' TEP problem solving skills	4.00	0.707	High	4.08	0.722	High
7.	The content of the module can be implemented appropriately	4.20	0.447	EH	3.94	0.762	High
8.	The content of the module is appropriate to the given time	4.20	0.837	EH	3.77	0.859	High
9.	The content of the module is appropriate to be used during learning and teaching session in classroom.	4.20	0.837	EH	4.02	0.737	High
10.	This module is able enhance students' understanding of the concepts learned	4.40	0.894	EH	4.10	0.691	High
11.	The content of this module meets the learning objectives of ED	4.60	0.548	EH	4.10	0.630	High
	Total mean	4.11	0.660	High	4.02	0.730	High

Note * H= High EH= Extremely high.

The findings show that both teachers and students felt that CAMED is highly suitable as a teaching aid for teaching and learning the subject of Engineering Drawing, with obtained mean value between 3.80 to 4.60. Table 3 displays the findings relating to the feasibility of CAMED in enhancing students' conceptual understanding, motivation, interest and self-esteem towards learning the subject of Engineering Drawing.

Table 3 Teachers' and students' views towards the use of CAMED in the teaching and learning of Engineering Drawing in enhancing students' conceptual understanding, motivation, interest and self esteem.

Code	Items	Teacher			Student		
		M	SD	Level	M	SD	Level
1.	Comprehension	3.95	0.381	High	3.91	0.767	High
2.	Motivation	4.00	0.342	High	3.91	0.771	High
3.	Self-esteem	3.95	0.381	High	3.93	0.780	High
4.	Interest	4.05	0.401	High	3.97	0.796	High
	Total mean	3.99	0.376	High	3.93	0.779	High

Note * H= High EH= Extremely high.

As indicated in Table 3, the teachers' and students' mean score towards the use of CAMED in increasing students' understanding, motivation, interest and self esteem is high (3.91-4.05), indicating that the developed CAMED manage to improve the teaching and learning of ED.

The findings based on the opened ended questions regarding the feasibility of the developed CAMED also support the quantitative analysis. On the whole, teachers gave positive reactions to the usefulness of CAMED namely it is able to facilitate students' understanding for each basic concepts in Geometrical Plane Drawing through the effective animation found in CAMED. The animation had help the students to learn step by step the techniques of Engineering Drawing, which also facilitated the explanation of the teachers. In addition the animation could be repeated for the students thus allowing the teachers to focus on helping the students to understand the concepts rather than spending time on drawing the diagrams manually.

The students also gave positive reaction to the usefulness of the developed CAMED. In particular they found that the developed module was able to develop their skills in engineering drawing and their understanding of the basic concepts. The developed CAMED also helped them to better solve problems related to the subject matter. In addition to acquring the related drawing skills (e.g. how to use the drawing instruments properly and ability to sketch), the students also said they found the subject to be more interesting since it is more easy to understand the subject matter through CAMED. Eventually, their interest, motivation and self esteem in learning Engineerign Design subject increased.

4.2 Results of the Effectiveness Study

4.2.1 Achievement Measure and Conceptual Understanding:

The effectiveness of the CAMED was tested by measuring student's mean score on ED achievement test meanwhile the mastery of concept and mastery of problem solving knowledge were measured using respective sections in the achievement post test. The result of independent t-test comparing experimental and control group is shown in Table 4.

Table 4 t-test for Post-Test on Overall Achievement Measure and Section of Conceptual Understanding between Experimental and Control Group

Achievement Test	Group	N	Mean	S.D	t-value	df	Sig.
Overall Achievement POST ED Test	K1	110	63.17	21.31	3.927	208.2	0.000*
	K2	109	53.16	17.019			
Conceptual Understanding TEP ED	K1	110	30.00	10.12	3.871	207.0	0.000*
	K2	109	25.23	8.02			
Conceptual Understanding TEP ED Q_TEP 1	K1	110	11.14	3.87	2.819	208.2	0.005*
	K2	109	9.80	3.11			
Conceptual Understanding TEP ED Q_TEP 2	K1	110	7.95	4.08	3.933	212	0.000*
	K2	109	5.94	3.46			
Conceptual Understanding TEP ED Q_TEP 3	K1	110	10.92	3.98	2.835	217	0.005*
	K2	109	9.49	3.47			

* Significant at $p<0.05$

The results of independent t-test show that there is significant difference on overall ED achievement test between the experimental group and control group at t(208.2) = 3.93, p<0.05. It appears that students in the experimental group score higher (M =63.17) than the control group (M= 53.16). This indicates that the CAMED module used in the experimental group had helped the students to understand the concepts better.

4.2.2 Effectiveness of CAMED on problem solving knowledge

Table 5 shows finding of independent t-test on the effectiveness of CAMED on acquiring problem solving knowledge.

Table 5 Analisis of independent t-test on mean scores of Problem solving knowledge

Dependent Variable	Group	N	Mean	S.D	t-value	(df)	Sig.
Problem Solving Knowledge TEP ED	G1	110	30.00	10.12	3.841	207.7	0.000*
	G2	109	25.25	8.08			
Mathematical Knowledge	G1	110	6.41	0.70	5.744	194.2	0.000*
	G2	109	5.74	0.99			
Conceptual Knowledge	G1	110	19.80	7.38	1.782	217	0.076
	G2	109	18.11	6.66			
Procedural Knowledge	G1	110	3.80	2.74	7.771	180.4	0.000*
	G2	109	1.41	1.67			

* Significant at p<0.05

The result reveals that there is a significant difference in the mean score of experimental group and control group on their problem solving knowledge after taking the post test at t(2007.7)=3.84, p<0.05 where the experimental group scores higher (M=30.0) than the control group (M=25.25). Furthermore, the analysis on parts of problem solving knowledge shows that there is an obvious significant difference in the mean score of mathematical problem solving of the experimental group (M=6.41) and control group (M=5.74) at t(194.2)=5.74, p<0.05. The experimental group also scored better (M=3.80) in procedural knowledge of problem solving as compared to the control group (M=1.41) at t(180.4)=7.77, p<0.05. Only for concept knowledge of TEP both group showed no significant difference. It seems that CAMED is appropriate to assist students in procedural knowledge as well as mathematical knowledge. Teaching conceptual knowledge for problem solving can be done both using CAMED and traditional approaches.

5 Discussion and Conclusion

Outcome of both the teachers' and students' evaluation of the developed module is very encouraging. Teachers and students perceived that CAMED is highly suitable as a form of aid for teachers to use to teach the subject and for students to use in learning the subject. CAMED was also found to increase students' interest and motivation towards learning Engineering Design subject.

The findings of the current study parallels with [25] which shows that effective use of multimedia courseware will lead to effective teaching and learning process. In particular, courseware when used effectively will be able to attract and increase students' interest in learning as well as facilitates learning. [26-27] also argued that effective use of multimedia will affect students' ability to interact socially. In addition according to [28] a learning module that is developed systematically, such as CAMED, can acts as a tool that is able to guide and motivate students towards change of behavior and achievement.

Elements of multimedia such as animation [29-30] has shown to be able to improve students' attention towards learning a difficult and abstract subject thus making the subject more interesting. In addition the use of CAMED has also increased

teachers' confidence in their teaching of Engineering Design which also leads to high confidence of students' towards their teachers' teaching.

The current study also demonstrated that the use of computer animation in teaching and learning has positive impact on the students' motivation, interest and self esteem. Previous studies also showed that the use of animation has improved students' motivation in learning [26], lessen the occurrence of misconceptions which leads to meaningful learning [30], potential to increase students' understanding in various disciplines [13] and has significant effect on students' achievement [18]. It is believed that the usage of visualization object is able to assist students to understand better of the concepts compared to reading from paper. The researchers further argued that teachers should use visualization tool in their teaching and learning activities since it can give a positive impact on students' motivation, achievement and problem solving ability. In conclusion, the developed CAMED could be used as an effective teaching aid in the teaching and learning of Engineering Drawing subject and it is seen as an innovation in teaching and learning in Engineering Drawing at schools.

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